2003 PASSING LANE PRIORITIZATION UPDATE

Final Report

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1. PROJECT OVERVIEW

PURPOSE

The Arizona Department of Transportation (ADOT) is required to compile a list of projects for its Five-Year Construction Program. This study identifies and prioritizes passing lane projects to be considered for inclusion in the Five-Year Construction Program. A process for prioritizing both climbing and passing lanes on the Arizona State Highway System was developed by the *1999-2000 Climbing/Passing Lane Study*. A list of prioritized climbing and passing lane projects was produced using the prioritization process. The 2003 study documented here updates the 1999-2000 prioritization of passing lane projects.

Listed below is the Technical Advisory Committee (TAC) that provided guidance on the project.

- Arnold Burnham, Priority Programming Manager, Transportation Planning Division
- Ron Casper, Safford District Engineer
- John Louis, Intermodal Transportation Division
- Donald Mauller, Priority Programming Team
- Jeff Swan, Holbrook Engineering District

PREVIOUS METHODOLOGY

The following documents conducted in 1999 and 2000 on prioritizing climbing lanes were reviewed and updated:

- *Technical Supplement: Passing Lanes/Climbing Lanes*, September 1999
- *Passing Lanes/Climbing Lanes: Preliminary Report*, January 2000
- *Passing Lanes/Climbing Lanes Supplemental Paper*, June 26, 2000

In Phase I, all State and US highways in Arizona were divided into several segments. ADOT's Highway Performance Monitoring System database (HPMS) was used for this purpose. Segments were defined using break points in average annual daily traffic (AADT), number of lanes, terrain, passing opportunity percentage, and truck percentage. Locations were ranked based on percentage of no passing length, current AADT, truck volume, accident rate, and terrain type. Data for the criteria was obtained from available ADOT databases. Level-of-service (LOS) was estimated based on a table of volume-to-capacity ratios versus service volumes from the *1997 Highway Capacity Manual (HCM)*. For ranking the candidate locations, points were assigned to each criterion for each project. For example, each project received points for current AADT, truck volume, level-of-service, terrain, percent grade, and passing related accidents. A total score for each candidate location was computed by summing the points for all the criteria and the candidate locations were ranked by ascending score. After review of Phase I methodology, ADOT districts recommended that the ranking

methodology be applied to a list of candidate locations selected by each district. As per the recommendations, each ADOT district was asked to provide at least five potential candidate locations for passing lanes based on their knowledge of highways in the district. Passing lane locations selected by each district were pooled together and Phase I methodology was applied to rank the passing lane locations.

Identified Issues

The following methodology issues for passing lanes were identified during the 1999-2000 study.

- Queuing length of vehicles was not reflected in the LOS methodology
- Highway speed limits rather than actual average-travel-speed was used
- Daily traffic volumes were not adjusted for seasonal and peak hour variation
- Future traffic volumes were not considered
- Accuracy of data was questioned
- Local jurisdiction input during the process of identification and ranking was lacked
- Identification of passing lanes for both two-lane highways and multilane highways

OVERVIEW OF REVISED METHODOLOGY

Issues mentioned in the previous study to identify and rank candidate passing lane locations are addressed in this update. For the purpose of this study, a passing lane is defined as:

> *Additional lane on highways to facilitate the passing of all types of slow moving vehicles at locations other than sustained grades where passing opportunities are unavailable or very limited over a long stretch of highway.*

For two-lane highways, lack of passing opportunities at regular intervals often results in long queues and poor performance. In lieu of costly widening projects, and in most cases, adding a passing lane at these locations alleviates the problem. However, for multilane highways, 'no passing' zones are not an issue and lack of capacity is the prime reason for it to perform at a lower level-of-service. Hence for this study, passing lanes were considered only on two-lane highways. The following summarizes the steps for identifying and prioritizing passing lanes on two-lane highways.

1. Identify the "universe" of candidate locations
2. Compare "universe" to passing lane candidate locations recommended by ADOT Engineering Districts
3. Select preliminary list of candidate locations from the "universe"
4. Filter preliminary list of candidate locations

5. Rank preliminary candidate passing lanes on two-lane highways
6. Compare preliminary candidates with candidates identified by ADOT districts
7. Review of preliminary candidates by ADOT districts
8. Prepare ultimate list of ranked candidate locations for passing lanes after districts review

The methodology for identifying and ranking the candidate passing lanes is described in the following chapter in more detail.

2. PASSING LANES ON TWO-LANE HIGHWAYS

This chapter presents the methodology for identifying and ranking candidate locations for passing lanes on two-lane highways. ***Locations identified for passing lanes in this project represent only the general problem area and not the exact location and length of the passing lanes.***

OVERVIEW

As previously mentioned, this study first reviewed the previous work to identify strengths and weaknesses of the previously defined methodology and then revised the methodology to improve the overall prioritization process. The quality of data was one of the issues in the previous study. For this study, special emphasis was given to the data collection and validation aspects. Data from various sources at ADOT was collected (Table 1). Geographic Information System (GIS) and database software were used for data integration and analysis.

TABLE 1. DATA ITEMS AND SOURCES

Data Items	ADOT Data Source
Number of Travel Lanes	Roadway Log
Annual Average Daily Traffic (AADT)	HPMS/Historical Traffic Volume Database
Passing Length, No Passing Length	Striping Database
Directional Distribution	HPMS/Historical Traffic Volume Database
K Factor	HPMS/Historical Traffic Volume Database
Seasonal Adjustment Factors	ADOT Data Center
Truck Percentage	HPMS/Historical Traffic Volume Database
Highway Geometrics	Roadway Log
Speed	Roadway Log
Terrain	HPMS
Accidents	ALISS Accident Database – Traffic Records

PROCESS

Using the data items listed in Table 1 and following the steps mentioned below, a "Universe" of preliminary candidate locations and the ultimate list of candidate locations were identified.

Step 1: Identify the "Universe" of Candidate Locations

Using GIS, the state highway system was divided into several segments based on break points in the data. For example, a section of highway from milepost (MP) 5 to MP 10 had identical values for AADT, number of lanes, and truck percentage, but from MP 7 to MP 10, the terrain type changed from level to rolling. In this instance, the highway was split into two segments: Segment 1 - from MP 5 to MP 7 and Segment 2 from MP 7 to MP 10. Resulting segments were of variable length. For analysis purposes, the segments were truncated to a

standard length of two miles each. This ensured equal weight to each segment being analyzed. Level-of-service was calculated for all segments based on a volume-to-capacity (VC) ratio method. Segments with a LOS of B or worse were selected to create the "Universe" of candidate locations.

Step 2: Compare "Universe" to Passing Lane Candidate Locations Recommended by ADOT Engineering Districts

Each ADOT Engineering district was requested to compile a list of candidate passing lane locations based on their knowledge of highways in their districts. A comparison of the district recommended passing lane locations list to the "Universe" of candidate locations revealed that approximately 90 percent of the sections identified by the districts were within a five mile vicinity of the candidate locations in the "Universe." For remaining sections, data was verified against other available sources, which included comparing data items such as traffic volumes, truck percentages, and seasonal traffic factors against historical data. After this verification, the percentage rose to 96 percent. Table 2 shows the list of candidate locations recommended by ADOT Engineering districts.

Step 3: Select Preliminary List of Candidate Locations from the "Universe"

The *1997 HCM* methods to determine LOS were used in the 1999 update of the Passing/Climbing Lanes Study. Those methods did not account for effects of queuing length and average-travel-speed on the performance of the highway. The *2000 HCM* procedures for two-lane highways estimate LOS based on two factors:

- *Percent-Time-Spent-Following* reflects the average percentage of time a vehicle on a highway spends following other vehicles. Percent-time-spent-following is estimated from the demand flow rate, the directional distribution of traffic, and the percentage of no-passing zones. Formulae to estimate the percent-time-spent-following listed in the 2000 HCM were used.

- *Average-Travel-Speed* represents the actual speed a vehicle achieves on a highway (not speed limit) after taking into consideration factors such as grade, percentage of no passing zones, traffic volumes etc. Formulae to estimate the average-travel-speed listed in the 2000 HCM were used.

The above factors reflect the effects of queuing and average-travel-speed on two-lane highways. Percent-time-spent-following and average-travel-speed were determined by data items such as daily traffic volume, truck percentage, passing/no passing length, directional distribution factor, peak-hour factor, highway geometrics, speed limit, and terrain as outlined in the *2000 HCM*. Traffic volumes were adjusted for seasonal variation. Default values as suggested in the *HCM* were used where actual data was not available. Percent-time-spent-following and average-travel-speed were used to determine the LOS for all candidate sections identified in step 1.

TABLE 2. PASSING LANE LOCATIONS RECOMMENDED BY ADOT DISTRICTS

ROUTE	DIR	BMP	EMP	DISTRICT
S 64	SB	187.80	189.00	Flagstaff
S 64	NB	196.30	198.20	Flagstaff
S 64	SB	200.30	202.30	Flagstaff
S 64	NB	202.50	204.70	Flagstaff
S 64	EB	213.50	218.50	Flagstaff
S 64	WB	215.50	220.50	Flagstaff
U 160	EB	314.50	319.50	Flagstaff
U 160	EB	336.50	341.50	Flagstaff
U 160	WB	338.50	343.50	Flagstaff
U 160	EB	350.70	352.10	Flagstaff
U 160	WB	355.50	356.90	Flagstaff
U 89A	NB	566.30	571.30	Flagstaff
S 077	NB	350.00	352.00	Globe
S 260	EB	372.00	374.00	Globe
U 060	EB	220.00	222.00	Globe
U 060	EB	305.00	307.00	Globe
U 060	EB	346.00	348.00	Globe
U 070	EB	268.00	270.00	Globe
S 264	EB	402.50	403.50	Holbrook
S 264	EB	454.50	460.00	Holbrook
S 87	NB	290.00	295.00	Holbrook
S 87	SB	290.00	295.00	Holbrook
U 160		362.00	374.00	Holbrook
U 160		384.00	393.00	Holbrook
U 160	WB	460.80	463.00	Holbrook
U 160		374.00	384.00	Holbrook
U 191	NB	375.50	377.00	Holbrook
U 191	NB	390.00	395.00	Holbrook
U 191	SB	443.00	447.00	Holbrook
S 95	NB	163.50	168.50	Kingman
S 95	NB	167.30	172.30	Kingman
S 95	SB	173.00	178.00	Kingman
S 95	NB	191.23	196.23	Kingman
S 169	EB	0.00	5.00	Prescott
S 260	EB	232.88	233.33	Prescott
S 87	SB	254.50	259.50	Prescott
S 87	NB	264.00	265.00	Prescott
S 87	SB	264.00	265.00	Prescott
S 87	SB	269.00	270.40	Prescott
S 87	NB	274.00	278.80	Prescott
S 87	SB	274.00	278.80	Prescott
S 89	NB	298.00	302.00	Prescott
S 89	SB	298.00	302.00	Prescott
S 89A	SB	345.00	350.00	Prescott
U 93	NB	193.50	198.50	Prescott
S 80	EB	335.00	337.00	Safford
S 77	NB	91.21	92.13	Tucson
S 77	NB	94.13	95.35	Tucson
S 95	NB	133.00	138.00	Yuma
S 95	SB	133.00	138.00	Yuma
U 95	NB	44.50	49.50	Yuma
U 95	SB	44.50	49.50	Yuma
U 95	NB	67.50	72.50	Yuma
U 95	SB	67.50	72.50	Yuma
U 95	NB	77.00	82.00	Yuma
U 95	SB	77.00	82.00	Yuma
U 95	NB	82.00	87.00	Yuma
U 95	SB	82.00	87.00	Yuma
U 95	NB	89.00	94.00	Yuma
U 95	SB	89.00	94.00	Yuma
U 95	NB	94.00	99.00	Yuma
U 95	SB	94.00	99.00	Yuma

Note: DIR is direction, BMP is Beginning Milepost, EMP is Ending Milepost.

All segments that had a level-of-service D or worse were selected to create a list of preliminary candidate locations for passing lanes. Table 3 shows the initial list of candidate locations for passing lanes on two-lane highways.

Step 4: Filter Preliminary List of Candidate Locations

Preliminary list of candidate locations were verified against ADOT's current Five-Year Construction Program projects. The "District/TAC Comments" field in Table 5 shows the programmed projects that made the preliminary list of candidates. These candidates were removed from the preliminary list in the ranking process.

TABLE 3. PRELIMINARY LIST OF CANDIDATE LOCATIONS FOR PASSING LANES ON TWO-LANE HIGHWAYS

District	Section ID	Route	Direction	BMP	EMP	District/TAC Comments (Programmed/Viable/Not Viable)
Flagstaff	S 064-NB-M196-M198	S 064	NB	196	198	Viable
Flagstaff	S 064-NB-M202-M204	S 064	NB	202	204	Viable
Flagstaff	S 064-NB-M238-M240	S 064	NB	239	240	Not Viable: Vicinity of Grand Canyon National Park
Flagstaff	S 064-SB-M189-M191	S 064	SB	189	191	Viable: Viable at MP 188 to MP 189
Flagstaff	S 064-SB-M200-M202	S 064	SB	200	202	Viable
Flagstaff	S 064-WB-M218-M220	S 064	WB	218	220	Viable: Programmed - FY04 Design; FY05 Construction
Flagstaff	S 098-EB-M299-M301	S 098	EB	299	301	Viable
Flagstaff	SA089-NB-M378-M380	S 89A	NB	378	380	Not Viable: Vicinity of Oak Creek Canyon
Flagstaff	SA089-NB-M390-M392	S 89A	NB	390	392	Viable
Flagstaff	U 089-NB-M452-M454	U 089	NB	452	454	Viable
Flagstaff	U 160-EB-M314-M316	U 160	EB	314	316	Viable
Globe	S 073-NB-M347-M349	S 073	NB	347	349	Viable
Globe	S 077-NB-M350-M352	S 077	NB	350	352	Viable
Globe	S 260-EB-M372-M374	S 260	EB	372	374	Viable
Globe	U 060-EB-M220-M222	U 060	EB	220	222	Viable
Globe	U 060-EB-M305-M307	U 060	EB	305	307	Viable
Globe	U 060-EB-M346-M348	U 060	EB	346	348	Viable: Programmed - FY05
Globe	U 070-EB-M268-M270	U 070	EB	268	270	Viable
Holbrook	S 264-EB-M377-M379	S 264	EB	377	379	Not Viable: Sensitive Area
Holbrook	S 264-EB-M402-M404	S 264	EB	402	404	Not Viable: High Rock Cut
Holbrook	S 264-EB-M444-M446	S 264	EB	444	446	Viable
Holbrook	S 264-EB-M454-M456	S 264	EB	454	456	Viable
Holbrook	U 160-EB-M362-M364	U 160	EB	362	364	Viable
Holbrook	U 160-EB-M384-M386	U 160	EB	384	386	Viable
Holbrook	U 160-WB-M462-M464	U 160	WB	462	464	Viable
Holbrook	U 191-NB-M375-M377	U 191	NB	375	377	Viable
Holbrook	U 191-NB-M390-M392	U 191	NB	390	392	Viable
Holbrook	U 191-NB-M431-M433	U 191	NB	431	433	Viable
Holbrook	U 191-SB-M441-M443	U 191	SB	441	443	Viable
Kingman	S 066-EB-M63-M65	S 066	EB	63	65	Viable: Candidate for Route Transfer to Local jurisdiction
Kingman	S 095-NB-M165-M167	S 095	NB	165	167	Viable: Programmed - FY04 Construction @ MP168

TABLE 3. PRELIMINARY LIST OF CANDIDATE LOCATIONS FOR PASSING LANES ON TWO-LANE HIGHWAYS (CONTINUED)

District	Section ID	Route	Direction	BMP	EMP	District/TAC Comments (Programmed/Viable/Not Viable)
Kingman	S 095-NB-M169-M171	S 095	NB	169	171	Viable: Programmed - FY04 Construction @ MP168
Kingman	S 095-NB-M191-M193	S 095	NB	191	193	Viable: Programmed - FY07
Kingman	S 095-SB-M174-M176	S 095	SB	174	176	Viable
Kingman	SA089-SB-M345-M347	S 89A	SB	345	347	Viable
Kingman	U 093-NB-M124-M126	U 093	NB	124	126	Viable: Programmed for widening to 4 Lanes - FY04
Kingman	U 093-NB-M165-M167	U 093	NB	165	167	Not Viable: Passing Lane Exists @ 167.7 -168.9
Kingman	U 093-NB-M5-M7	U 093	NB	5	7	Viable: Programmed - Roadway Design FY06
Phoenix Maintenance	S 074-EB-M27-M29	S 074	EB	27	29	Viable
Phoenix Maintenance	S 088-EB-M208-M210	S 088	EB	208	210	Not Viable
Prescott	S 087-NB-M264-M266	S 087	NB	264	266	Viable: Programmed - FY06 @ MP263
Prescott	S 087-NB-M269-M271	S 087	NB	269	271	Viable
Prescott	S 087-NB-M274-M276	S 087	NB	274	276	Viable
Prescott	S 087-NB-M288-M290	S 087	NB	288	290	Viable
Prescott	S 087-SB-M254-M256	S 087	SB	254	256	Viable
Prescott	S 089-NB-M302-M304	S 089	NB	302	304	Viable
Prescott	S 260-EB-M211-M213	S 260	EB	211	213	Viable: Programmed - FY08
Prescott	S 260-EB-M257-M259	S 260	EB	257	259	Viable: But planned for 4 Lanes
Prescott	S 260-EB-M271-M273	S 260	EB	271	273	Viable: But planned for 4 Lanes
Prescott	S 260-EB-M299-M301	S 260	EB	299	301	Viable
Prescott	U 093-NB-M196-M198	U 093	NB	195	198	Viable
Safford	S 080-EB-M334-M336	S 080	EB	334	336	Viable: Expensive
Safford	S 080-EB-M345-M347	S 080	EB	345	347	Not Viable: Not a Problem Area
Safford	S 090-EB-M293-M295	S 090	EB	293	295	Not Viable: Currently 4 Lane Divided Roadway
Safford	S 090-EB-M302-M304	S 090	EB	302	304	Not Viable: Currently 4 Lane Divided Roadway
Safford	S 090-EB-M309-M311	S 090	EB	309	311	Not Viable: Rural/Urban Area
Safford	S 090-EB-M327-M329	S 090	EB	327	329	Not Viable: San Pedro Bridge and 2 Left Turn Bays Exist
Safford	U 191-NB-M114-M116	U 191	NB	114	116	Not Viable: Urban/ Rural Area
Tucson	S 077-NB-M92-M94	S 077	NB	92	94	Viable
Tucson	S 077-NB-M94-M96	S 077	NB	94	96	Viable
Tucson	S 086-EB-M153-M155	S 086	EB	153	155	Not Viable: Does Not Qualify

Step 5: Rank Preliminary Candidate Passing Lanes on Two-Lane Highways

The candidate passing lane locations were ranked using performance criteria shown in Table 4. Level-of-service, percent-time-spent-following, and average-travel-speed were obtained from step 3. Total accidents and passing related accidents for all preliminary candidate locations were extracted from ADOT's ALISS accident database for a period of five years between 1998 and 2002. Accident rate was calculated for each segment using total accidents and existing daily traffic volumes.

TABLE 4. PERFORMANCE CRITERIA FOR RANKING CANDIDATE PASSING LANE LOCATIONS ON TWO-LANE HIGHWAYS

Performance Criteria	Maximum Number of Points
Mobility (Existing level-of-service)	5
Percent-time-spent-following	10
Average-travel-speed	5
Passing related accidents	10
Accident rate	10

The following steps were carried out to determine the relative ranks of the candidate locations:

1. For each performance criterion, a Z score, or standard score, was computed for a candidate location. The Z score indicates how far the data for the criterion deviates from the mean of all the candidate locations, and in which direction, plus or minus. The Z score is helpful in comparing the relative performance of the candidates in respect to a specific criterion, such as accidents.
2. Based on a maximum number of points for the criterion, points were computed based on the Z score for each criterion for the candidate location. Maximum number of points used for each criterion is shown in Table 4.
3. A total score for the candidate was computed by summing the points across the four criteria.
4. The candidates were then rank ordered according to the total scores and placed in one of three tiers of equal score increments.

Appendix A discusses in more detail the ranking methodology.

Step 6: Compare Preliminary Candidates with Candidates Identified By ADOT Districts

The preliminary candidate passing lane locations for two-lane highways were compared with the segments identified by the ADOT Engineering Districts. For sections recommended by ADOT districts and that were not in the preliminary candidates list, data items were verified from all available sources. Further evaluation was conducted on a case by case basis for data items such as AADT, grade, truck percentage etc.

Step 7: Review of Preliminary Candidates by ADOT Districts

Preliminary list of the ranked candidate locations were sent to ADOT Engineering Districts for review of the following:

- Candidate location programmed or scoped for passing lanes or widening
- Passing lane already exist
- Viability or constructability based on filtering criteria listed below:

Filtering Criteria

- Are there constraints in proximity to a candidate location that make the location not viable such as intersections, turn bays, physical constraints?
- Are there opportunities to locate a passing lane on one side of the road?
- Are bridges and culverts if they result in shoulder width restriction avoided?
- Does the passing lane location appear logical to the driver?
- Are sections with low-speed curves avoided?
- Are passing lane sections that are not feasible or cost effective avoided?
- Are sections in urban areas avoided?

The "District/TAC Comments" column in Table 3 shows the district comments regarding the viability of each candidate location based on filtering criteria.

Step 8: Ultimate List of Ranked Candidate Locations for Passing Lanes after Districts Review

After ADOT Engineering Districts review of the preliminary candidate locations, the ultimate list of candidate locations for passing lanes on two-lane highways was prepared by eliminating all segments that were either programmed or deemed not viable. The ultimate list of candidate locations was re-ranked using the procedures outlined in step 5. Table 5 presents the rankings of the ultimate list of candidate locations for two-lane highways. The Table also shows the data for each performance criteria, assigned points for each criterion, and total score for candidate locations. The candidate locations were placed in one of three tiers of equal score intervals. Tier definitions used in this process are shown at the bottom of Table 5. Table 6 displays the ultimate list of candidate locations sorted by the rank and score obtained for each candidate location. Figure 1 illustrates the candidate passing lane locations, color coded by tier, and located to the side of the highway representing the direction in which the passing lane is recommended. For example, the passing lane recommended on SR 77 at MP 350-352 is displayed on the right side of the highway, meaning the passing lane should be placed on the northbound direction.

TABLE 5. ULTIMATE LIST OF PASSING LANE LOCATIONS ON TWO-LANE HIGHWAYS

Candidate Location Information Passing Lanes on Two-Lane Highways							Mobility			Percent-Time-Spent-Following		Average-Travel-Speed		Passing Related Accidents		Accident Rate		Score, Rank, and Tier		
							LOS A = 0 LOS B = 1 LOS C = 2 LOS D = 3 LOS E = 4 LOS F = 5	Average St. Dev. Points	3.41 0.50 5	Average St. Dev. Points	67.39 12.21 10	Average St. Dev Points	39.63 3.72 5	Average St. Dev Points	1.11 1.52 10	Average St. Dev. Points	2.35 3.96 10	Min. Rank: Max Rank: Difference # of Tiers:	13.71 28.14 14.43 3	
District	Initial District Recommendation	Route	Direction	Section ID	Beginning Milepost	Ending Milepost	Existing LOS/VC	LOS Points	Assigned Points	Percent-Time-Spent-Following	Assigned Points	Average-Travel-Speed	Assigned Points	Passing Related Accidents	Assigned Points	Accident Rate	Assigned Points	Score	Rank	Tier
Flagstaff	Yes	S 064	NB	S 064-NB-M196-M198	196	198	D	3.0	1.82	75	6.10	42	1.94	1	4.88	1.45	4.62	19.36	19	Tier 2
Flagstaff	Yes	S 064	NB	S 064-NB-M202-M204	202	204	D	3.0	1.82	75	6.01	42	1.89	0	3.79	0.29	4.13	17.65	25	Tier 3
Flagstaff	Yes	S 064	SB	S 064-SB-M189-M191	189	191	D	3.0	1.82	75	6.01	42	1.89	1	4.88	3.09	5.31	19.92	17	Tier 2
Flagstaff	Yes	S 064	SB	S 064-SB-M200-M202	200	202	D	3.0	1.82	75	6.01	42	1.89	1	4.88	2.90	5.23	19.84	18	Tier 2
Flagstaff	No	S 098	EB	S 098-EB-M299-M301	299	301	D	3.0	1.82	63	4.37	44	1.56	0	3.79	0.98	4.42	15.95	33	Tier 3
Flagstaff	Yes	S 089A	NB	SA089-NB-M390-M392	390	392	E	4.0	3.50	76	6.14	38	2.94	5	9.26	2.50	5.06	26.90	3	Tier 1
Flagstaff	No	U 089	NB	U 089-NB-M452-M454	452	454	E	4.0	3.50	94	8.70	30	4.72	2	5.98	0.31	4.14	27.03	2	Tier 1
Flagstaff	Yes	U 160	EB	U 160-EB-M314-M316	314	316	D	3.0	1.82	65	4.74	40	2.34	0	3.79	0.09	4.05	16.74	30	Tier 3
Globe	No	S 073	NB	S 073-NB-M347-M349	347	349	D	3.0	1.82	69	5.23	43	1.76	0	3.79	0.57	4.25	16.85	28	Tier 3
Globe	Yes	S 077	NB	S 077-NB-M350-M352	350	352	E	4.0	3.50	89	7.92	35	3.54	0	3.79	2.12	4.90	23.65	7	Tier 1
Globe	Yes	S 260	EB	S 260-EB-M372-M374	372	374	D	3.0	1.82	59	3.91	40	2.43	1	4.88	2.99	5.27	18.31	23	Tier 3
Globe	Yes	U 060	EB	U 060-EB-M220-M222	220	222	E	4.0	3.50	83	7.16	39	2.69	1	4.88	0.54	4.24	22.46	9	Tier 2
Globe	Yes	U 060	EB	U 060-EB-M305-M307	305	307	E	4.0	3.50	63	4.45	39	2.65	1	4.88	1.83	4.78	20.26	15	Tier 2
Globe	Yes	U 070	EB	U 070-EB-M268-M270	268	270	D	3.0	1.82	63	4.42	44	1.62	0	3.79	1.69	4.72	16.37	31	Tier 3
Holbrook	No	S 264	EB	S 264-EB-M444-M446	444	446	E	4.0	3.50	77	6.28	34	3.85	0	3.79	0.94	4.41	21.83	10	Tier 2
Holbrook	Yes	S 264	EB	S 264-EB-M454-M456	454	456	D	3.0	1.82	66	4.87	41	2.21	0	3.79	0.63	4.28	16.96	27	Tier 3
Holbrook	Yes	U 160	EB	U 160-EB-M362-M364	362	364	E	4.0	3.50	64	4.52	39	2.55	1	4.88	1.44	4.62	20.07	16	Tier 2
Holbrook	Yes	U 160	EB	U 160-EB-M384-M386	384	386	E	4.0	3.50	65	4.66	39	2.60	0	3.79	0.87	4.38	18.92	21	Tier 2
Holbrook	Yes	U 160	WB	U 160-WB-M462-M464	462	464	D	3.0	1.82	66	4.82	45	1.28	0	3.79	1.40	4.60	16.32	32	Tier 3
Holbrook	Yes	U 191	NB	U 191-NB-M375-M377	375	377	D	3.0	1.82	41	1.46	41	2.19	0	3.79	1.04	4.45	13.71	37	Tier 3
Holbrook	Yes	U 191	NB	U 191-NB-M390-M392	390	392	D	3.0	1.82	49	2.47	41	2.15	1	4.88	1.46	4.63	15.95	34	Tier 3
Holbrook	No	U 191	NB	U 191-NB-M431-M433	431	433	D	3.0	1.82	58	3.74	41	2.25	0	3.79	0.17	4.08	15.68	35	Tier 3
Holbrook	Yes	U 191	SB	U 191-SB-M441-M443	441	443	D	3.0	1.82	56	3.49	41	2.09	2	5.98	0.67	4.29	17.67	24	Tier 3
Kingman	No	S 066	EB	S 066-EB-M63-M65	63	65	D	3.0	1.82	75	6.07	43	1.83	0	3.79	0.22	4.10	17.62	26	Tier 3
Kingman	Yes	S 095	SB	S 095-SB-M174-M176	174	176	E	4.0	3.50	63	4.36	38	2.79	1	4.88	2.43	5.03	20.56	13	Tier 2
Phoenix Maintenance	No	S 074	EB	S 074-EB-M27-M29	27	29	D	3.0	1.82	65	4.73	40	2.46	2	5.98	0.72	4.31	19.30	20	Tier 2
Prescott	Yes	S 087	NB	S 087-NB-M269-M271	269	271	E	4.0	3.50	66	4.78	37	3.15	2	5.98	3.34	5.41	22.82	8	Tier 2
Prescott	Yes	S 087	NB	S 087-NB-M274-M276	274	276	D	3.0	1.82	52	2.90	41	2.12	0	3.79	1.93	4.82	15.45	36	Tier 3
Prescott	Yes	S 087	NB	S 087-NB-M288-M290	288	290	D	3.0	1.82	52	2.91	44	1.59	0	3.79	6.33	6.67	16.78	29	Tier 3
Prescott	Yes	S 087	SB	S 087-SB-M254-M256	254	256	E	4.0	3.50	64	4.58	36	3.25	0	3.79	4.52	5.91	21.03	12	Tier 2
Prescott	Yes	S 089	NB	S 089-NB-M302-M304	302	304	D	3.0	1.82	44	1.76	42	1.94	5	9.26	24.40	10.00	24.77	5	Tier 1

TABLE 5. ULTIMATE LIST OF PASSING LANE LOCATIONS ON TWO-LANE HIGHWAYS (CONTINUED)

Candidate Location Information Passing Lanes on Two-Lane Highways							Mobility			Percent-Time-Spent-Following		Average-Travel-Speed		Passing Related Accidents		Accident Rate		Score, Rank, and Tier		
							LOS A = 0 LOS B = 1 LOS C = 2 LOS D = 3 LOS E = 4 LOS F = 5	Average St. Dev. Points	3.41 0.50 5	Average St. Dev. Points	67.39 12.21 10	Average St. Dev Points	39.63 3.72 5	Average St. Dev Points	1.11 1.52 10	Average St. Dev. Points	2.35 3.96 10	Min. Rank: Max Rank: Difference # of Tiers:	13.71 28.14 14.43 3	
District	Initial District Recommendation	Route	Direction	Section ID	Beginning Milepost	Ending Milepost	Existing LOS/VC	LOS Points	Assigned Points	Percent-Time-Spent-Following	Assigned Points	Average-Travel-Speed	Assigned Points	Passing Related Accidents	Assigned Points	Accident Rate	Assigned Points	Score	Rank	Tier
Prescott	No	S 260	EB	S 260-EB-M299-M301	299	301	E	4.0	3.50	75	6.06	36	3.32	0	3.79	2.40	5.02	21.68	11	Tier 2
Prescott	Yes	S 089A	SB	SA089-SB-M345-M347	345	347	E	4.0	3.50	55	3.32	38	2.96	0	3.79	3.03	5.29	18.85	22	Tier 2
Prescott	Yes	U 093	NB	U 093-NB-M196-M198	195	198	D	3.0	1.82	77	6.26	42	1.92	5	9.26	2.58	5.10	24.36	6	Tier 1
Safford	Yes	S 080	EB	S 080-EB-M334-M336	334	336	D	3.0	1.82	64	4.60	44	1.57	3.	7.07	3.36	5.42	20.49	14	Tier 2
Tucson	Yes	S 077	NB	S 077-NB-M92-M94	92	94	E	4.0	3.50	86	7.48	32	4.22	2	5.98	0.75	4.33	25.50	4	Tier 1
Tucson	Yes	S 077	NB	S 077-NB-M94-M96	94	96	E	4.0	3.5	87	7.72	31	4.33	4	8.16	0.99	4.43	28.14	1	Tire 1

Range of tiers for passing lanes on two-lane highways:

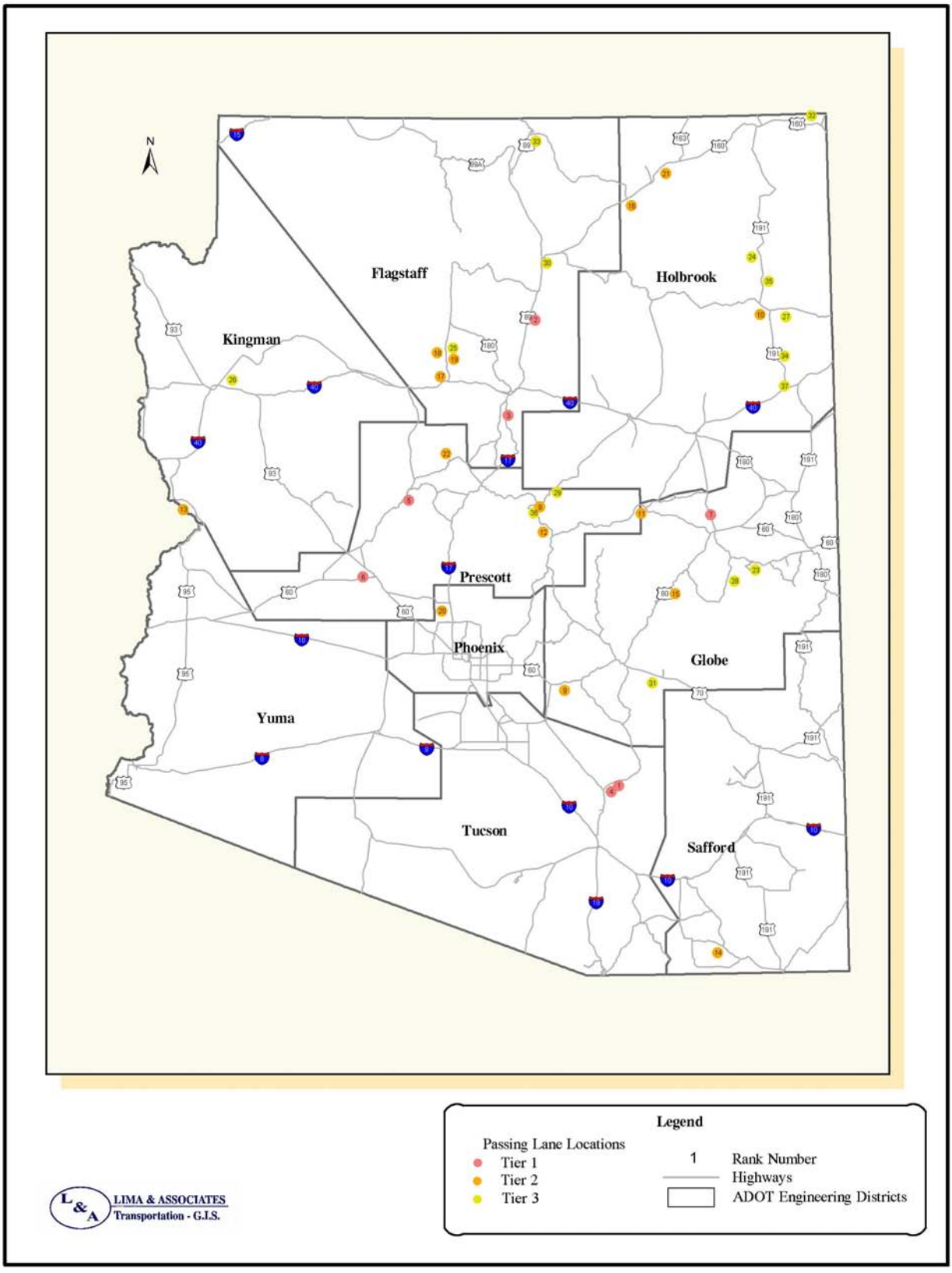
Tier Increment: 4.81

Tier 1: 28.14 – 23.33
Tier 2: 23.33 – 18.52
Tier 3: 18.52 – 13.71

TABLE 6. RANKING OF CANDIDATE LOCATIONS FOR PASSING LANES ON TWO-LANE HIGHWAYS

District	Route	Direction	Section ID	BMP	EMP	Score	Rank	Tier
Tucson	**S 077**	NB	S 077-NB-M94-M96	94	96	28.14	**1**	Tier 1
Flagstaff	**U 089**	NB	U 089-NB-M452-M454	452	454	27.03	**2**	Tier 1
Flagstaff	**S 89A**	NB	SA089-NB-M390-M392	390	392	26.90	**3**	Tier 1
Tucson	**S 077**	NB	S 077-NB-M92-M94	92	94	25.50	**4**	Tier 1
Prescott	**S 089**	NB	S 089-NB-M302-M304	302	304	24.77	**5**	Tier 1
Prescott	**U 093**	NB	U 093-NB-M196-M198	195	198	24.36	**6**	Tier 1
Globe	**S 077**	NB	S 077-NB-M350-M352	350	352	23.65	**7**	Tier 1
Prescott	**S 087**	NB	S 087-NB-M269-M271	269	271	22.82	**8**	Tier 2
Globe	**U 060**	EB	U 060-EB-M220-M222	220	222	22.46	**9**	Tier 2
Holbrook	**S 264**	EB	S 264-EB-M444-M446	444	446	21.83	**10**	Tier 2
Prescott	**S 260**	EB	S 260-EB-M299-M301	299	301	21.68	**11**	Tier 2
Prescott	**S 087**	SB	S 087-SB-M254-M256	254	256	21.03	**12**	Tier 2
Kingman	**S 095**	SB	S 095-SB-M174-M176	174	176	20.56	**13**	Tier 2
Safford	**S 080**	EB	S 080-EB-M334-M336	334	336	20.49	**14**	Tier 2
Globe	**U 060**	EB	U 060-EB-M305-M307	305	307	20.26	**15**	Tier 2
Holbrook	**U 160**	EB	U 160-EB-M362-M364	362	364	20.07	**16**	Tier 2
Flagstaff	**S 064**	SB	S 064-SB-M189-M191	189	191	19.92	**17**	Tier 2
Flagstaff	**S 064**	SB	S 064-SB-M200-M202	200	202	19.84	**18**	Tier 2
Flagstaff	**S 064**	NB	S 064-NB-M196-M198	196	198	19.36	**19**	Tier 2
Phoenix Maintenance	**S 074**	EB	S 074-EB-M27-M29	27	29	19.30	**20**	Tier 2
Holbrook	**U 160**	EB	U 160-EB-M384-M386	384	386	18.92	**21**	Tier 2
Prescott	**S 89A**	SB	SA089-SB-M345-M347	345	347	18.85	**22**	Tier 2
Globe	**S 260**	EB	S 260-EB-M372-M374	372	374	18.31	**23**	Tier 3
Holbrook	**U 191**	SB	U 191-SB-M441-M443	441	443	17.67	**24**	Tier 3
Flagstaff	**S 064**	NB	S 064-NB-M202-M204	202	204	17.65	**25**	Tier 3
Kingman	**S 066**	EB	S 066-EB-M63-M65	63	65	17.62	**26**	Tier 3
Holbrook	**S 264**	EB	S 264-EB-M454-M456	454	456	16.96	**27**	Tier 3
Globe	**S 073**	NB	S 073-NB-M347-M349	347	349	16.85	**28**	Tier 3
Prescott	**S 087**	NB	S 087-NB-M288-M290	288	290	16.78	**29**	Tier 3
Flagstaff	**U 160**	EB	U 160-EB-M314-M316	314	316	16.74	**30**	Tier 3
Globe	**U 070**	EB	U 070-EB-M268-M270	268	270	16.37	**31**	Tier 3
Holbrook	**U 160**	WB	U 160-WB-M462-M464	462	464	16.32	**32**	Tier 3
Flagstaff	**S 098**	EB	S 098-EB-M299-M301	299	301	15.95	**33**	Tier 3
Holbrook	**U 191**	NB	U 191-NB-M390-M392	390	392	15.95	**34**	Tier 3
Holbrook	**U 191**	NB	U 191-NB-M431-M433	431	433	15.68	**35**	Tier 3
Prescott	**S 087**	NB	S 087-NB-M274-M276	274	276	15.45	**36**	Tier 3
Holbrook	**U 191**	NB	U 191-NB-M375-M377	375	377	13.71	**37**	Tier 3

FIGURE 1. PASSING LANE CANDIDATE LOCATIONS FOR TWO-LANE HIGHWAYS



SUMMARY OF FINDINGS

The study identified a total of 37 potential candidate locations for passing lanes on Arizona's State Highway System. As mentioned earlier, these locations represent the general problem area and not the exact location and length of the passing lanes. Detailed analysis is needed to identify the exact location and length of the passing lane. To further assist ADOT in prioritizing the locations, the candidate were ranked and grouped into three tiers. Tier 1 candidates represent the locations with the highest priority and Tier 3 represents candidates with the lowest priority.

Candidate locations identified by the study were compared with those identified by ADOT Engineering Districts as a measure to validate the methodology for current and future use. Comparison results presented in Step 2 of the process validates the methodology used to identify candidate locations for passing lanes. Some segments recommended by ADOT Engineering Districts did not qualify for the ultimate list. Some of the possible reasons are:

- Location lacked updated data
- Location already existed in the vicinity of the general problem area
- Location was recommended considering future year traffic volumes and not existing conditions. This study did not account for future traffic volumes.

This study recommends that ADOT use one of the following methods for future updates-

- Update the data items for current candidate locations and re-rank the locations
- Request each ADOT Engineering District to update the candidates identified in this study. Re-rank the new candidates using updated data.

APPENDIX A. RANKING METHODOLOGY

RANKING METHODOLOGY

The methodology used in this rating system compares basic performance data about each project against all other submitted projects. The following categories are considered in the methodology:

- Current level-of-service
- Future level-of-service
- Accident rates
- Strategic criteria such as Level of Development, Functional Class, and National Highway System

The established goal categories are represented through a number of points. To start out with, each category is assigned the same number of points, meaning that all categories are equally important. Once data items are collected for each project the statistical procedure of a Z score is applied to assign a certain number of points to each project. Thus, reflecting the ranking of the particular project in each of the goal categories. In other words, the project with the greatest need of improvement in a certain category will receive the highest number of points in that category. This method allows ranking quantitative criteria, such as "accident rate" as well as qualitative criteria such as the "strategic goal". The impacts of a project on the strategic goal are translated in a numeric value, which in turn is used to assign "criteria" points.

Scoring

For each data category, a Z-score is calculated, which is then used to distribute category points. For example, average and standard deviation across all projects for the mobility category is calculated. An assigned number of points are then distributed according to the distribution of individual values. Individual scores are then calculated for mobility, safety (accident rate), and strategic information (subtotal of all factors). The overall score is calculated by adding up the mobility, safety, and strategic score.

Ranking

A rank for each project is calculated based on the overall score. The project with the highest score is ranked number 1.

Tier System

In order to avoid controversy over small differences in final project scores and subsequent ranking a "Tier" system is applied. This system assigns each project to a group or tier. Currently, an approach is used which creates three (3) groups or tiers based on the spread of

scores. The difference between the lowest and highest project score is used to calculate the range of project scores. This range of project scores is then divided by the number of groups resulting in range intervals.

Example:

Score 1 = 20 highest score
Score 2 = 12
Score 3 = 17
Score 4 = 7
Score 5 = 5 lowest score

highest score minus lowest score:	20 – 5 = 15
divided by the number of tiers, assume three:	15 ÷ 3 = 5
determines range interval:	Tier 3: 5-10 Tier 2: 10-15 Tier 1: 15- 20

REFERENCES

American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets*, Washington D.C., 2001.

Transportation Research Board, *2000 Highway Capacity Manual*, National Research Council, Washington D.C., 2000.